

Cardiac Vagal Control Among Migrants: Associations With Mainstream Acculturation and Perceived Ethnic Discrimination

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Objective: This cross-sectional study examines associations between cardiac vagal control and mainstream acculturation by systematically investigating the independent contributions of resting, reactivity, and recovery Respiratory Sinus Arrhythmia (RSA)—physiological factors contributing to adaptive functioning, including social engagement capacity. This study also examines the moderating role of RSA reactivity in associations between perceived ethnic discrimination and mainstream acculturation. **Method:** The sample comprised 111 migrants from Maghreb (Morocco, Algeria, and Tunisia) to Montreal, QC, Canada. On average, participants (60 women) were 31 years old and had immigrated 7 years prior to the study. The study design was cross-sectional. We collected both psychophysiological (electrocardiogram) and self-report questionnaire data. **Results:** All three facets of cardiac vagal control are independently associated with mainstream acculturation: Higher mainstream acculturation was associated with higher resting RSA ($\beta = .24$), lower RSA reactivity ($\beta = -.27$), and higher recovery RSA ($\beta = .26$), controlling for several theoretically relevant covariates. Furthermore, lower RSA reactivity to a discrimination-recall task dampened the relation between perceived discrimination and mainstream acculturation (interaction $\beta = -.20$). **Conclusions:** This study replicates and extends prior work linking RSA and mainstream acculturation using a sample of racialized and marginalized migrants. It provides evidence that RSA is related to migrants' adoption of the mainstream culture and may modulate how they handle perceived ethnic discrimination. Thus, this study also provides evidence that RSA is tied to how individuals successfully navigate novel social environments, including novel cultural contexts.

Keywords: respiratory sinus arrhythmia, acculturation, perceived ethnic discrimination, migration, Maghreb

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Public Significance Statement

Respiratory sinus arrhythmia (RSA)—a biomarker of cardiac vagal control that has been conceptualized as an index of a neurophysiological system supporting self-regulation during social interactions—may influence migrants' adaptation to a new cultural environment. In addition, lower social sensitivity—indexed by lower RSA reactivity in response to a stressor—may help buffer the negative impact of ethnic discrimination on migrants' adoption of the new culture. Our data suggest that one's physiological states—as indexed by RSA—are associated with mainstream acculturation among Maghrebi migrants to Canada. The findings highlight that in addition to social and psychological factors, acculturation is a process also influenced by physiological factors.

How do migrants successfully navigate their new cultural environment? How do they make new friends, learn new cultural norms, and renegotiate their cultural identities? How

do they learn to “fit in” in the new society, often in spite of substantial difficulties and discrimination? Replicating and extending our prior work linking respiratory sinus arrhythmia (RSA) and mainstream acculturation (Doucerain et al., 2016), we propose that cardiac vagal control, an index of parasympathetic functioning, influences acculturation processes among migrants. Different theoretical frameworks have conceptualized RSA as an index of a neurophysiological system supporting self-regulation (Thayer et al., 2009) as well as social engagement behaviors (Muhtadie et al., 2015; Porges, 2011). We investigate how the “three Rs” of cardiac vagal control (Laborde et al., 2018)—resting, reactivity, and recovery RSA—are related to mainstream acculturation and how migrants manage perceived discrimination during their acculturation journey.

Identifying the antecedents of mainstream acculturation is essential. Most countries in the global North are home to substantial migrant populations, and mainstream acculturation is positively associated with migrants' psychosocial adjustment (Nguyen & Benet-Martínez, 2013), while also

contributing to the larger society's cohesion (Kirmayer et al., 2011). Further, mainstream acculturation can serve as a model for the successful navigation of novel social environments, a ubiquitous aspect of human functioning even outside of immigration contexts. Therefore, better understanding the physiological antecedents of mainstream acculturation is both socially and theoretically relevant.

Mainstream Acculturation

Acculturation is defined as the change process resulting from prolonged exposure to a cultural context different from the one in which a person has been socialized (Schwartz et al., 2010). In the case of migrants, this includes changes in language practices, norms, values, identities, social relationships, and behaviors. In many industrialized societies, acculturation touches a substantial proportion of the population. For example, 22% of Canada's population is foreign-born (Statistics Canada, 2017a). The dominant theoretical framework in acculturation research (Berry, 2005) distinguishes between mainstream and heritage acculturation, depending on the cultural stream with respect to which the above changes operate (i.e., cultural adoption vs. maintenance). We focus here on mainstream acculturation, or the degree to which migrants adopt the new society's dominant cultural stream.

In their broad review of acculturation, Sam and Berry (2010, p. 479) stress that research on acculturation's antecedents is scarce, with some work on sociodemographic (e.g., age at immigration, economic status, or immigration class; Berry & Hou, 2016) or personality variables (e.g., need for cognitive closure; Kopic, 2006). Given the conceptualization of mainstream acculturation as an implicit cultural

learning process taking place through sustained social engagement and interactions in the mainstream cultural group (Doucerain, 2019), individual differences in social engagement capacity may influence mainstream acculturation. Social engagement refers here to a person's participation in a range of social roles, relationships and activities within a social/cultural community (Hartwell & Benson, 2007).

Mainstream acculturation is also strongly shaped by its sociocultural context (Ward & Geeraert, 2016), in particular by how welcoming that context is to migrants. Migrants who experience more ethnic discrimination or unfair treatment due to one's ethnic and/or cultural characteristics—report less mainstream acculturation (Berry & Hou, 2016; Jasinskaja-Lahti et al., 2003; Neto, 2002; Te Lindert et al., 2008; Verkuyten & Yildiz, 2007). As a form of group rejection, ethnic discrimination can result in stronger heritage cultural in-group identification, which in turn is associated with less commitment to the mainstream society (Verkuyten & Yildiz, 2007). The extensive replication of this negative association under-scores that perceived discrimination is a ubiquitous obstacle to migrants' social functioning in their new country (United Nations, 2011). In the global North, many migrants come from racialized groups, making it more likely that they will face ethnic discrimination during their acculturation journey. In Canada, one in five migrants reports having experienced some form of discrimination, with racialized minorities being twice as likely to face discrimination than their non-racialized counterparts (Nangia, 2013). Given the negative impact of perceived ethnic discrimination on mainstream acculturation, research on the factors that can alleviate this adverse effect is needed.

Cardiac Vagal Control Respiratory sinus arrhythmia (RSA), indexing cardiac vagal control, reflects the activity of a neurophysiological system involved in allostasis and related to various facets of self-regulation during social interactions (Smith et al., 2020). RSA may also influence mainstream acculturation. Cardiac vagal control refers to the contribution of the parasympathetic nervous system to cardiac regulation through the vagus nerve. It is commonly measured using high-frequency heart rate variability, or RSA. RSA reflects naturally occurring variations in heart rate tied to the breathing cycle. At rest, there is a tonic inhibitory output to the sinoatrial node—the heart pacemaker—through the vagal nerve. During inspiration, the inhibitory influence of the vagus nerve is temporarily lifted, increasing heart rate. Conversely, greater vagal-dependent parasympathetic output during expiration causes a transient decrease in heart rate. RSA thus reflects the strength of the vagal parasympathetic output underlying these systematic fluctuations in interbeat intervals during the respiration cycle (Berntson et al., 1997).

Recent reviews have described the role of parasympathetic activity in self-regulation, including during social in-

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teractions (Balzarotti et al., 2017; Beauchaine et al., 2019; Smith et al., 2020; Williams et al., 2019). We focus here on social functioning, given its conceptual overlap with mainstream acculturation. Two influential theories have linked RSA to social functioning broadly speaking. Polyvagal Theory (Porges, 2011) posits that over the course of vertebrate evolution, brain stem nuclei involved in cardiac control became increasingly connected with facial muscles and related anatomical structures involved in emotion expression and social communication (e.g., soft palate, larynx). Regulation of cardiac activity through the vagus nerve permitted the coordination of physiological and behavioral states supporting social engagement responses. Therefore, Polyvagal Theory conceptualizes RSA as a biomarker of this neurophysiological system supporting social engagement behaviors (Porges, 2007, 2011). The Neurovisceral Integration Model (Thayer et al., 2009) rests on the notion that prefrontal inhibition of limbic activity, involved in self-regulation, is reflected in changes in RSA. In this model, greater RSA reflects greater activity and integration of a neural network involved in cognitive, affective, and autonomic regulation in response to changing environmental demands. More recently, emphasizing the psychobiology of stress, the Generalized Unhappiness Theory of Stress has proposed that higher resting RSA reflects general perceptions of safety versus threat (Brosschot et al., 2017). As Smith et al. (2020) point out, these perspectives are complementary, a common key insight being that the “vagus nerve is intimately involved in regulating humans’ emotional responses to their social environment” (Muhtadie et al., 2015, p. 110).

Our prior work has shown that RSA is associated with mainstream acculturation among new migrants. In a longitudinal study among newly arrived international students, baseline resting RSA was prospectively associated with greater increases in mainstream acculturation over time (Doucerain et al., 2016). This study aims to replicate and extend these findings in three ways. Our initial work was conducted with a highly selected group of university students during the early phase of acculturation, whereas we focus here on a community sample in a racialized cultural minority. Second, RSA may differently impact mainstream acculturation in the context of negative discrimination experiences within the novel cultural environment. Third, different measures of RSA have been differentially associated with social functioning in prior work. Based on vagal tank theory (Laborde et al., 2018), resting, reactivity, and recovery RSA may be differentially associated with mainstream acculturation.

Resting RSA

Resting, or tonic RSA, refers to a person’s baseline cardiac vagal control level and is usually measured while sitting calmly. In line with Polyvagal Theory and the Neurovisceral Integration Model, higher resting RSA has been associated

with better social functioning and self-regulation, across a range of indicators including emotion recognition (Quintana et al., 2012), prosocial behavior (Beauchaine et al., 2013), attachment security (Diamond & Hicks, 2005; Maunder et al., 2012), and positive marital functioning (Diamond et al., 2011; Smith et al., 2011).

Mainstream acculturation rests to a large extent on the ability to form new relationships and to socially engage in a new sociocultural environment. In past research, in a sample of newly arrived international students, we found that resting RSA was prospectively associated with greater increases in mainstream acculturation over time (Doucerain et al., 2016). We seek to replicate this effect among migrants who have been living in a novel cultural environment for several months.

RSA Reactivity

RSA reactivity (also called phasic RSA or vagal withdrawal) refers to changes in cardiac vagal control in response to a challenge. In response to stress or metabolically demanding tasks, such as exercise or information processing, withdrawal of the vagal brake, resulting in RSA decreases, allows the organism to quickly regulate its metabolic output to meet the demands at hand. In the realm of social functioning—our focus here—both greater and lower RSA reactivity can be adaptive depending on the situation. For example, a meta-analysis showed that greater RSA reactivity is associated with fewer social problems among community/healthy children, but with more social problems among clinic/at-risk children (Graziano & Derefinko, 2013). Muhtadie et al. (2015) propose that greater RSA reactivity reflects greater sensitivity to social context. They found that compared to participants with less RSA reactivity, those with greater RSA reactivity displayed more prosocial behaviors when they received positive social feedback during a stress task, but fewer such behaviors when social feedback was negative (Muhtadie et al., 2015). Similarly, in the context of interpersonal functioning, individuals with high RSA reactivity were more sensitive to the lack of positive interactions than those with lower reactivity (Gouin et al., 2019).

Mainstream acculturation requires successfully navigating novel social situations, on a daily basis and without well-established social schemas as guides (Doucerain, 2019). For migrants experiencing ethnic discrimination, social interactions in the mainstream group are often not just challenging but can be downright hostile. How migrants subjectively handle these discriminatory episodes may influence whether they disengage from the mainstream society and retreat in their heritage group (Neto, 2002; Verkuyten Yildiz, 2007), or persist participating in the mainstream group. Stress exposure is associated with less trust, in particular toward out-group members (Steinbeis et al., 2015). When facing discrimination, being less sensitive to hostile social interactions

may help sustain engagement in that context and therefore facilitate mainstream acculturation.

Although informed by social functioning conceptualizations of RSA, such a moderation effect would also be consistent with the Generalized Unsafty Theory of Stress (Brosschot et al., 2017). Physiologically perceiving discriminatory episodes as less threatening (i.e., lower RSA reactivity) might also help maintain social engagement in the mainstream culture. Similarly, Vagal Tank Theory, drawing on the Neurovisceral Integration Model (Thayer et al., 2009), postulates that in situations with heavy emotion regulation demands, smaller RSA suppression, or even RSA augmentation indicates better self-regulation (Laborde et al., 2018; shown empirically in Park et al., 2014). Thus, lower RSA reactivity may reflect a greater ability to effectively deploy self-regulatory resources in response to discrimination. These conceptual models suggest that lower RSA reactivity in response to discrimination-related stress could foster mainstream acculturation by buffering the well-documented negative association between perceived discrimination and mainstream acculturation.

RSA Recovery

RSA recovery refers to the restoration of cardiac vagal control following a challenge. Like reactivity, recovery is key to an organism's adaptability. Using the vagal tank metaphor, recovery reflects whether people "fill their tank quickly enough to face another stressor, in order to have enough ability to self-regulate and react effectively" (Laborde et al., 2018, p. 5). Research on the role of RSA recovery in social functioning is scarce, and neither Polyvagal Theory nor the Neurovisceral Integration Model make explicit predictions regarding that aspect of cardiac vagal control. Polyvagal Theory sets forth that rapid and transient fluctuations in RSA are optimal (Porges, 2007), which could be extended to mean that RSA recovery should ideally be prompt. Accordingly, Vagal Tank Theory suggests that quickly going back to an initial or improved level of cardiac vagal control level reflects better self-regulation and is therefore more adaptive (Laborde et al., 2018). Given that mainstream acculturation is a prolonged process unfolding over years and involving frequent taxing social interactions in the mainstream group (Doucerein, 2019), the ability to recover after social and cultural stressors may be key to sustaining engagement in the novel cultural context.

Covariates and Cultural Specificity

A number of contextual factors can influence RSA both acutely and chronically. For example, greater psychosocial stressors (e.g., lower socioeconomic status), more deprived social experiences (e.g., greater loneliness), and greater psychological distress (e.g., presence of depression) are associated with diminished cardiac vagal control (Gouin et al.,

2015; Kemp et al., 2010; Sloan et al., 2005)—in addition to age and gender differences (Umetani et al., 1998). In order to identify independent associations between the RSA variables and acculturation, we considered the potentially confounding effects of a range of factors when examining associations between RSA and mainstream acculturation. Specifically, we include perceived social status, education level, work status, legal status in the country, relationship status, presence of family in the region, and psychological adjustment as covariates in all analyses. We also test the cultural specificity of the hypothesized effects by examining associations between RSA and heritage acculturation. Indeed, migrants' maintenance of their heritage culture likely reflects the coalesced influence of socialization and family histories, idiosyncratic experiences, personal values, etc., rather than their ability to explore a novel cultural context—which we propose is facilitated by RSA.

The Present Study

This study tests the overarching hypothesis that cardiac vagal control indexes a suite of physiological processes that facilitate navigating a novel social environment—here, mainstream acculturation. We test this hypothesis by systematically investigating the independent contributions of resting, reactivity, and recovery RSA. Building on Polyvagal Theory and the Neurovisceral Integration Model, Vagal Tank Theory postulates that these three components reflect different physiological mechanisms underpinning adaptability in novel social contexts (Laborde et al., 2018) and informs the hypotheses below. Note that all effects are expected to hold controlling for covariates identified earlier.

Hypothesis 1: Resting RSA will be positively associated with mainstream acculturation, conceptually replicating our prior work.

Hypothesis 2: Smaller RSA reactivity in response to a stress task will be associated with greater mainstream acculturation.

Hypothesis 3: The negative association between perceived discrimination and mainstream acculturation will diminish as RSA reactivity decreases.

Hypothesis 4: Better RSA recovery (smaller changes, or even increases between baseline and recovery RSA) will be associated with greater mainstream acculturation.

Hypothesis 5: RSA variables will be more strongly associated with mainstream acculturation than with heritage acculturation.

We conducted this study among Maghrebi migrants living in Quebec, Canada for several reasons. First, because of colonial history, most migrants from Morocco, Algeria, and Tunisia (the three countries included here) are fluent in French, Quebec's official and dominant language. This allows us to parcel out the role of language proficiency, a key variable in acculturation research (Kang, 2006), at the design level. Second, belonging to a racialized group, Maghrebi migrants face unique difficulties tied to the current political, social and economic climate. They have one of the highest unemployment rates among Quebec cultural minorities—despite degrees higher than or equivalent to the national average. They also report high rates of perceived discrimination (Valiante, 2017). This demographic group is therefore a socially and theoretically meaningful population to investigate how different aspects of cardiac vagal control are involved in mainstream acculturation.

Method

Participants

Adults born in Morocco, Algeria, or Tunisia and currently living in the greater Montreal area were recruited via classified ads and posters in the community (original $N = 117$). We excluded six participants due to unscorable physiological data (loss of electrocardiogram signal from a loose electrode lead), leaving 111 participants for the analyses (60 women; $M_{age} = 30.6$; $SD_{age} = 8.4$). Most participants were born in Morocco (67%, or 60.36%), 39 were born in Algeria (35.14%), and five in Tunisia (4.50%). On average, participants had been living in Canada for 6.7 years ($SD = 6.7$, range = 0–27) and most were naturalized citizens (45 vs. 35 permanent residents and 31 with other statuses such as holding a work permit). In terms of education, 109 participants had completed at least postsecondary education (98.20%), and 73 of them had completed a bachelor's degree or above (65.77%), reflecting an education level substantially higher than the national average (28.5%; Statistics Canada, 2017b). In terms of work status, 50 participants were studying, 42 were working (26 full-time, 16 part-time), and 19 had other work statuses such as unemployed or homemaker. About a third of our sample was married/cohabiting (39 participants), whereas the rest self-reported as single or other (e.g., divorced). Finally, participants were fairly evenly split between those who had some family in the greater Montreal region (52%) and those who didn't (48%).

Procedure

Participants completed a laboratory visit to assess RSA. They were instructed not to drink caffeine or smoke for 2 hr prior to their laboratory visit. After giving informed consent, they were fitted with electrodes for electrocardiogram

(ECG) recording and seated in a comfortable chair. After approximately 5 min of acclimation to the testing environment, ECG recordings were collected during a 5-min baseline resting period. Afterward, participants completed a discrimination recall task, first reflecting upon their discrimination experiences for 5 min (ECG recordings were collected during this 5-min stress-induction period) and then recounting these experiences to the research assistant for 3.03 min on average ($SD = 3.37$, range = 1.02–10.78). Following this, participants underwent a recovery period during which they were instructed to remain seated and relax during a 5-min period, while ECG recordings were collected. Finally, participants completed questionnaires on their immigration experience and adaptation to Canada. This project received approval from the university's ethical review board and participants provided consent prior to the beginning of data collection. Participants received CAD20 as compensation for their time. Specific task instructions are available as Supplemental Materials.

Materials

Questionnaires for Variables of Interest

The Brief Acculturation Orientation scale (Demes & Geeraert, 2014) measures heritage (BAOS-H; Cronbach $\alpha = .79$) and mainstream (BAOS-M; Cronbach $\alpha = .80$) acculturation. Each subscale comprises four items with mirror wording, such as "It is important for me to have [country of origin]/[mainstream] friends," scored on a 7-point Likert-type scale ranging from 1 = *strongly disagree* to 7 = *strongly agree*.

The Everyday Discrimination Scale (EDS; Williams et al., 1997) measures experiences of unfair treatment because of one's ethnocultural background. Participants rate the frequency of nine experiences such as "receiving poorer service than other people at restaurants or stores" on a 5-point Likert-type scale ranging from 0 = *never* to 5 = *almost every day* (Cronbach $\alpha = .88$).

Respiratory Sinus Arrhythmia

Participants were fitted with three electrodes in a modified lead II configuration. ECG data were collected using a wireless ECG amplifier module (BioNomadix Pair) and the BioPac MP150 data acquisition unit at a sampling rate of 1,000 Hz (BIOPAC Systems Inc., Goleta, CA). Interbeat intervals were recorded continuously during the three 5-min periods: Resting baseline, stress-induction, and recovery period). RSA data were analyzed using the Acq-Knowledge software, Version 4 (BIOPAC Systems). Trained research assistants visually inspected the digitized ECG signal and identified and corrected recording artifacts (less than 2% of the data were corrected). RSA was extracted using a Fast Fourier

Transformation (FFT) to obtain power in the 0.12 to 0.40 frequency range (Malik et al., 1996), for each 30-s epoch within each recording period. Resting RSA refers to baseline RSA. RSA reactivity was computed as the difference between resting RSA and stress-induction RSA, with greater scores indexing greater RSA decreases during the task. Recovery RSA was computed as the difference between RSA during the recovery period and resting RSA, with greater scores indexing a return to levels above resting RSA.

Covariates

We assessed subjective social status with the MacArthur Scale of Subjective Social Status (MSSSS; Adler et al., 2000), whereby participants locate their position on a metaphorical social status ladder on a $1 = \text{lowest status}$ to $9 = \text{highest status scale}$. Psychological adjustment was measured using the Brief Psychological Adaptation Scale (BPAS; Demes & Geeraert, 2014). Participants rate the frequency of 8 experiences such as feeling “happy with your day-to-day life in Canada” on a Likert-type scale ranging from $1 = \text{Never}$ to $7 = \text{Always}$ (Cronbach $\alpha = .88$). Participants indicated the highest degree they completed, which we recoded as number of years of education required (e.g., bachelor = 16 years in Quebec). Participants also reported their work status (categories full-time, part-time, studying, and other), legal status in Canada (categories citizen, permanent resident, and other), relationship status (categories married/cohabiting and single/other), and whether they had family in the greater Montreal area (categories some and none).

Analysis Plan

Our previous study detected an association of $r = .27$ between resting RSA and change in mainstream acculturation (Doucerain et al., 2016). We planned to collect enough data to detect a similar effect size, that is, at least $N = 104.5$ participants ($\alpha = .05$, $1 - \beta = .80$). With a sample size of $N = 111$, power was deemed sufficient for the present study. All analyses were conducted using R version 4.0.3 (R Core Team, 2020). The study’s data and analysis code are available at: <https://osf.io/zj27q/>.

No multivariate outliers were identified, based on Mahalanobis distances evaluated at $p < .001$. Missing data were minimal (1.9%) and missing completely at random, based on the results of nonparametric tests of homogeneity of covariance, $p = .34$ (Jamshidian & Jalal, 2010). They were imputed using expectation maximization to preserve power.

We used hierarchical regressions to test all hypotheses, with covariates entered in a first step and predictors of interest in subsequent steps. We conducted analyses pertaining to RSA reactivity and RSA recovery in separate regression sets, because of multicollinearity issues when both were included in a single model (Variance Inflation Factor or VIF > 2.50). During the discrimination-recall task, participants varied in

how long they recounted their memories to the experimenter. To avoid potential confounds between this variability and RSA recovery effects, we included time delay between the end of the stress-induction period and the beginning of the post-task period (in minutes) as a covariate when entering RSA recovery.

We verified assumptions of the linear model using model diagnostics and visual inspections of regression residuals, provided by packages *car* (Fox & Weisberg, 2019) and *performance* (Lüdtke et al., 2021). Residuals were normally distributed and homoscedastic across fitted values levels, $p = .37$ for Breusch-Pagan test (Breusch & Pagan, 1979). VIF values were all < 2.50 except for number of years in Canada and legal status in Canada. Given that these variables are covariates and that their VIF was < 5 (James et al., 2017), no further measures were taken.

Finally, given documented variations in experiences of discrimination and acculturation by gender and years in the new country (Brondolo et al., 2015), we tested models with interaction terms between RSA variables and sex/years in Canada. Given that none of these interaction terms were significant ($ps > .20$), they were not kept in the final models.

Results

As shown in Table 1, participants reported fairly high levels of heritage and mainstream acculturation, as well as low levels of discrimination. The discrimination recall task elicited a statistically significant decrease in RSA, $t(111) = 3.96$, $p < .001$, but recovery RSA was not significantly different from resting RSA, $t(111) = 0.97$, $p = .33$. Correlations (also displayed in Table 1) went in expected directions. Higher BAOS-M scores (mainstream acculturation) were associated with higher resting RSA and RSA recovery. Correlations between BAOS-M scores and RSA reactivity, as well as EDS scores (perceived discrimination) were negative, although statistically nonsignificant. None of the RSA variables were associated with BAOS-H scores (heritage acculturation). EDS scores were negatively correlated with BPAS (psychological adjustment) and BAOS-M scores with time in Canada. The latter correlation is at odds with the general idea that mainstream acculturation increases over time. However, it is consistent with results obtained among Russian migrants to Canada (Doucerain, 2020) and with qualitative accounts of some participants describing strong initial motivation and efforts to integrate into the mainstream group, gradually waning over time as they face obstacles (such as discrimination) and struggle establishing meaningful social ties in that group.

Table 2 displays the results of multiple regressions predicting BAOS-M scores (mainstream acculturation). None of the covariates entered in a first step were statistically significant, although Model 0 was significant overall, $F(15, 95) = 1.855$, $p = .038$.

Table 1*Spearman Correlations Among Numerical Study Variables and Descriptive Statistics*

Variable	<i>M</i> (<i>SD</i>)	2	3	4	5	6	7	8	9	10	11	12	13
1. Resting RSA	7.2(1.24)	0.39***	-0.17	-0.03	0.26**	0.07	-0.01	-0.09	-0.09	-0.05	0.00	-0.03	0.02
2. RSA reactivity	0.35(0.94)		-0.68***	-0.20*	-0.12	0.05	-0.07	0.04	0.04	-0.03	0.16	-0.11	-0.27**
3. RSA recovery	0.17(0.82)			-0.05	0.25**	-0.06	0.11	-0.10	-0.07	0.12	-0.05	0.12	0.17
4. EDS (perceived discrimination)	1.86(1.03)				-0.05	-0.07	-0.08	0.07	0.03	-0.17	-0.30**	-0.05	0.07
5. BAOS-M (mainstream acculturation)	5.21(1.35)					0.11	0.01	-0.26**	-0.05	0.13	0.12	0.12	0.10
6. BAOS-H (heritage acculturation)	5.08(1.59)						0.03	0.19*	-0.08	0.03	-0.15	0.22*	0.02
7. Age	30.53(8.42)							0.23*	0.13	-0.09	0.05	0.28**	0.07
8. Years in Canada	6.66(6.7)								-0.30**	-0.06	0.09	0.14	-0.07
9. Education level (years)	15.86(2.7)									0.10	-0.04	-0.19*	0.29**
10. MSSSS (social status)	5.67(1.61)										0.12	-0.08	0.17
11. BPAS (psychological adjustment)	5.05(1.21)											0.07	-0.13
12. Body mass index	23.68(3.9)												-0.05
13. Post-task time delay (minutes)	8.54(6.53)												

Note. Entries represent correlations among variables, except for the first column, which displays variables' mean and standard deviation. RSA = respiratory sinus arrhythmia; EDS = Everyday Discrimination Scale; BAOS = Brief Acculturation Orientation Scale; MSSSS = MacArthur Scale of Subjective Social Status; BPAS = Brief Psychological Adaptation Scale $p < .05$. ** $p < .01$. *** $p < .001$.

Hypothesis 1

Resting RSA was independently and positively associated with BAOS-M scores after taking covariates into account, $\beta = .24$, 95% CI [0.04, 0.40], $p = .01$, increasing R^2 by .05 (Model 1). Thus, supporting Hypothesis 1, participants with higher resting RSA values reported greater mainstream acculturation, with a semipartial correlation of .23.

Hypothesis 2

The introduction of RSA reactivity in Model 2 accounted for 5% additional variance in BAOS-M scores, with a semipartial correlation of -.23. The negative statistically significant coefficient, $\beta = -.27$ 95% CI [-.47, -.07], $p = .008$, indicates that smaller RSA reactivity during the discrimination recall task was associated with greater mainstream acculturation. This is consistent with Hypothesis 2.

Hypothesis 3

RSA reactivity moderated the association between EDS scores (perceived discrimination) and mainstream acculturation, $\beta = -0.20$, 95% CI [-0.38, -0.02], $p = .03$. Adding EDS and its interaction with RSA reactivity accounted for an additional 4% in explained variance (Model 3). In support of Hypothesis 3, Figure 1 shows that perceiving more discrimination was related to lower mainstream acculturation for participants with large RSA reactivity to our discrimination-focused stress task, simple slope $B(SE) = -.40(0.21)$, $p = .059$ at $M_{RSA\text{reactivity}} - 1 SD_{RSA\text{reactivity}}$. In contrast, perceived discrimination levels were unrelated to mainstream acculturation for participants with low RSA reactivity, simple slope $B(SE) = .13(0.15)$, $p = .37$ at $M_{RSA\text{reactivity}} + 1 SD_{RSA\text{reactivity}}$.

In other words, the association between perceived discrimination and mainstream acculturation became increasingly weak as RSA reactivity to the discrimination recall task diminishes. Based on the Johnson-Neyman interval, this association lost statistical significance when RSA reactivity was 1.47 (or 1.1 SD above the mean).

Hypothesis 4

Adding RSA recovery and time between the end of the stressinduction period and the beginning of the post-task period in Model 4 explained an additional 7% variance in BAOS-M scores. Controlling for this delay variable and those included in Model 2, RSA recovery was positively and statistically significantly associated with BAOS-M scores, $\beta = .26$, 95% CI [0.08, 0.44], $p = .006$. Supporting Hypothesis 4, this indicates that participants' whose post-task RSA values were closer to or higher than their baseline values reported greater mainstream acculturation. The semi-partial correlation for this effect was .24.

Hypothesis 5

To test the cultural specificity of the above effects, we also ran the regressions reported in Table 2 with BAOS-H scores (heritage acculturation) as the dependent variable. None of the coefficients for RSA variables were statistically significantly (all $ps > .12$). This is consistent with Hypothesis 5 and indicates that the role of resting RSA, RSA reactivity, and RSA recovery was specific to the mainstream cultural context.

Table 2

Hierarchical Multiple Regressions Predicting BAOS-M Scores (Mainstream Acculturation)

Predictor	Model 0	Model 1	Model 2	Model 3	Model 4
Intercept	4.85 *** [3.98; 5.73]	4.88 *** [4.04; 5.73]	4.82 *** [4.00; 5.65]	4.85 *** [4.04; 5.67]	4.69 *** [3.84; 5.53]
Age	0.01 [-0.03; 0.05]	0.00 [-0.03; 0.04]	0.00 [-0.04; 0.04]	-0.00 [-0.04; 0.04]	0.00 [-0.04; 0.04]
Sex (male vs. female)	0.08 [-0.44; 0.60]	0.21 [-0.31; 0.72]	0.34 [-0.17; 0.84]	0.29 [-0.22; 0.79]	0.33 [-0.17; 0.83]
Years in Canada	-0.05 [-0.11; 0.01]	-0.05 [-0.11; 0.01]	-0.04 [-0.10; 0.02]	-0.04 [-0.10; 0.01]	-0.03 [-0.09; 0.03]
Body mass index	0.01 [-0.06; 0.08]	0.02 [-0.05; 0.09]	0.01 [-0.05; 0.08]	0.02 [-0.05; 0.09]	0.01 [-0.05; 0.08]
Education level (years)	-0.07 [-0.17; 0.04]	-0.05 [-0.15; 0.05]	-0.03 [-0.13; 0.07]	-0.04 [-0.14; 0.06]	-0.04 [-0.15; 0.06]
MSSSS (social status)	0.14 [-0.02; 0.29]	0.15 [-0.01; 0.30]	0.14 [-0.01; 0.29]	0.10 [-0.05; 0.25]	0.10 [-0.05; 0.26]
Work status (other vs. full-time)	0.52 [-0.27; 1.31]	0.53 [-0.24; 1.30]	0.54 [-0.20; 1.28]	0.49 [-0.24; 1.22]	0.62 [-0.11; 1.36]
Work status (part-time vs. full-time)	0.57 [-0.32; 1.46]	0.55 [-0.32; 1.41]	0.46 [-0.38; 1.30]	0.57 [-0.27; 1.40]	0.69 [-0.16; 1.53]
Work status (studying vs. full-time)	0.42 [-0.25; 1.09]	0.28 [-0.38; 0.94]	0.22 [-0.43; 0.86]	0.23 [-0.41; 0.87]	0.34 [-0.30; 0.98]
Legal status (other vs. citizen)	-0.03 [-1.00; 0.94]	-0.13 [-1.07; 0.82]	-0.17 [-1.08; 0.75]	-0.27 [-1.18; 0.64]	-0.06 [-0.97; 0.85]
Legal status (perm. resident vs. citizen)	0.53 [-0.37; 1.43]	0.49 [-0.38; 1.37]	0.45 [-0.40; 1.30]	0.46 [-0.38; 1.30]	0.52 [-0.32; 1.37]
Family in area (some vs. none)	-0.21 [-0.78; 0.36]	-0.21 [-0.76; 0.35]	-0.20 [-0.74; 0.34]	-0.19 [-0.73; 0.35]	-0.27 [-0.80; 0.26]
Relationship status (single vs. married)	-0.14 [-0.74; 0.46]	-0.12 [-0.70; 0.46]	-0.03 [-0.60; 0.54]	-0.11 [-0.68; 0.46]	0.00 [-0.57; 0.58]
BPAS (psychological adjustment)	0.11 [-0.11; 0.32]	0.09 [-0.11; 0.30]	0.15 [-0.06; 0.35]	0.10 [-0.11; 0.32]	0.13 [-0.07; 0.33]
BAOS-H (heritage acculturation)	0.16 [-0.01; 0.32]	0.15 [-0.02; 0.31]	0.17 * [0.01; 0.33]	0.19 * [0.03; 0.35]	0.17 * [0.01; 0.33]
Resting RSA		0.26 * [0.06; 0.46]	0.39 *** [0.18; 0.61]	0.39 *** [0.17; 0.60]	0.32 ** [0.12; 0.52]
RSA reactivity			-0.38 ** [-0.67; -0.10]	-0.42 ** [-0.70; -0.14]	
EDS (perceived discrimination)				-0.13 [-0.40; 0.14]	
RSA reactivity × EDS				-0.28 * [-0.53; -0.03]	
RSA recovery					0.43 ** [0.13; 0.73]
Post-task time delay (minutes)					0.02 [-0.02; 0.06]
R ²	0.23	0.28	0.33	0.37	0.35

Note. Values are unstandardized coefficients and associated 95% confidence intervals in brackets. Continuous predictors are mean centered. BAOS = Brief Acculturation Orientation Scale; MSSSS = MacArthur Scale of Subjective Social Status; BPAS = Brief Psychological Adaptation Scale; RSA = respiratory sinus arrhythmia; EDS = Everyday Discrimination Scale. $p < .05$. ** $p < .01$. *** $p < .001$.

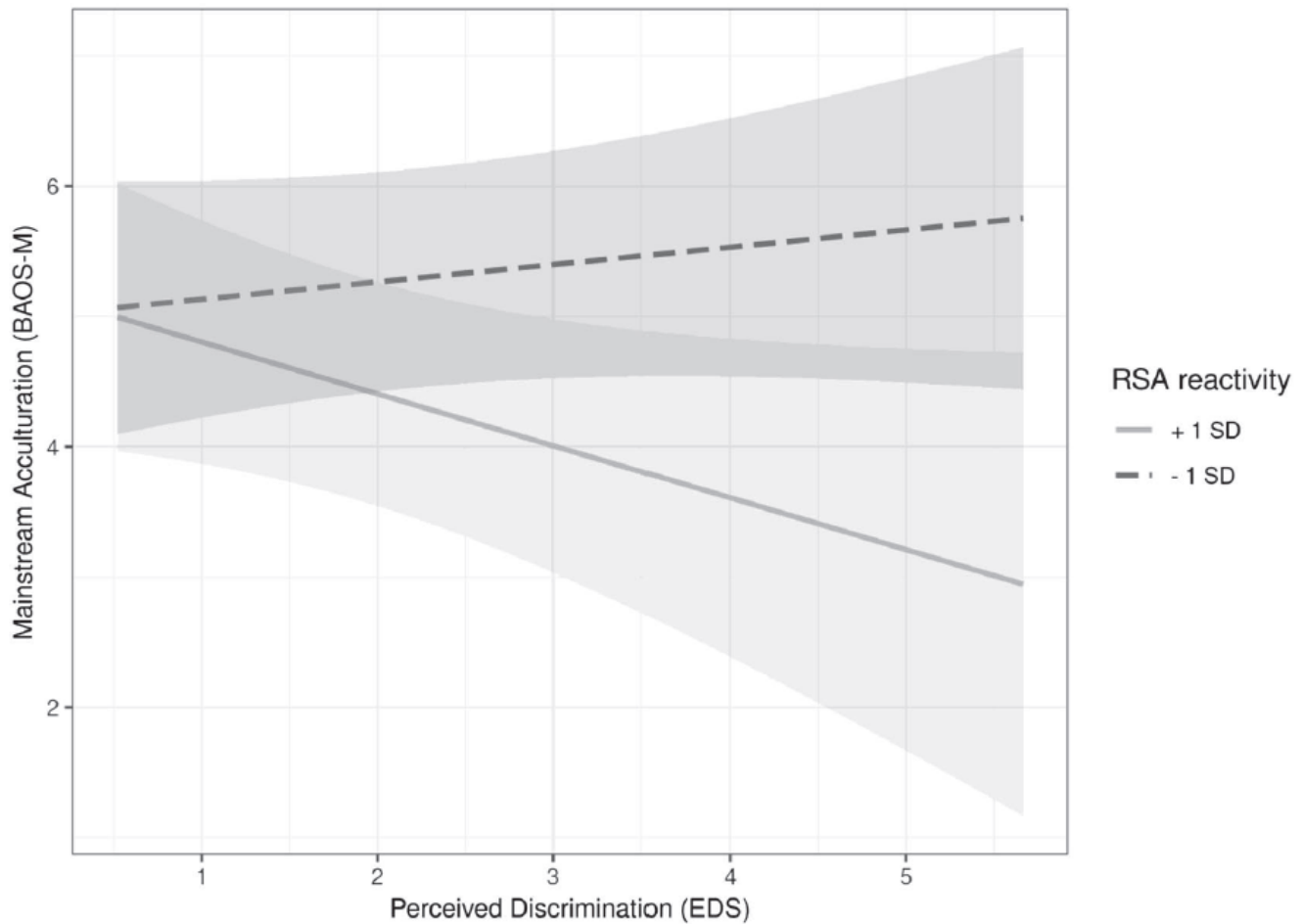
Discussion

This study investigated associations between mainstream acculturation and resting, reactivity, and recovery RSA among racialized migrants to Canada. Higher mainstream acculturation was associated with higher resting RSA, lower RSA reactivity, and higher recovery RSA. Furthermore, lower RSA reactivity to a discrimination-recall task moderated the association between perceived discrimination and mainstream acculturation such that the relation between these variables was attenuated among participants with lower RSA reactivity. These effects were specific to mainstream acculturation and not present for heritage acculturation. These findings provide evidence that RSA is tied to how individuals successfully navigate novel cultural contexts.

Our prior work indicated that higher baseline resting RSA prospectively predicted longitudinal increases in mainstream acculturation during the early stages of acculturation (Doucerain et al., 2016). Here, we replicated this positive association between resting RSA and mainstream acculturation in a sample of racialized and marginalized immigrants living in a novel cultural environment for several years, speaking to the robustness of this effect across cultural groups and immigration contexts. Given ties between resting RSA, regulation during social interactions, and social engagement capacity (Porges, 2011; Thayer et al., 2009), these findings are consistent with the notion that sustained social interactions with the mainstream group may be a key mechanism underlying

mainstream acculturation (Doucerain, 2019).

Lower RSA reactivity to the discrimination recall task was associated with more mainstream acculturation and buffered the negative association between perceived discrimination and mainstream acculturation. The role of RSA reactivity to a challenge in social settings is complex (Graziano & Derefinko, 2013). Muhtadie et al. (2015) argued that greater RSA reactivity is associated with more prosocial behaviors in a positive social environment, but fewer prosocial behaviors in a negative social environment. In partial support of this contention, our results suggest that in a challenging novel social context, lower RSA reactivity to a discrimination-related stressor—potentially reflecting better mobilization of selfregulatory resources—may be more favorable than greater reactivity. Lower RSA reactivity was also associated with greater mainstream acculturation overall. In stressed samples, excessive RSA reactivity to an emotional task may be associated with poorer emotional and social outcomes (Beauchaine, 2015; Gouin et al., 2014). Furthermore, theoretical perspectives on RSA reactivity set forth that whether greater or lower reactivity is desirable depends on the level of metabolic and cognitive demands of the task (Laborde et al., 2018; Thayer et al., 2009). The present results, together with Muhtadie et al. findings (2015), suggest that to better understand context-dependent RSA benefits, we may also need to consider the level of social threat associated with or surrounding the task.

Figure 1*RSA Reactivity Moderating the Association Between Perceived Discrimination and Mainstream Acculturation*

Note. RSA = respiratory sinus arrhythmia..

Perceived ethnic discrimination does not impact migrants' psychological health equally (Noh & Kaspar, 2003). Here, smaller RSA reactivity to a discrimination-recall task dampened the negative association between discrimination and mainstream acculturation. The mechanisms underlying this moderation would need to be clarified. Individuals with lower RSA reactivity may experience less emotional distress from discrimination experiences (Gouin et al., 2014), they may be better at regulating their emotions (Graham et al., 2015), or they may be better able to maintain positive social behaviors in the context of stressful interpersonal interactions (Diamond et al., 2011). At the same time, RSA reactivity itself is to some extent a product of individuals' experiences and their environment. Thus, it is also plausible that our stress task would be particularly stressful for people who experience (and report) high levels of discrimination, re-

sulting in greater decreases in RSA. Future research should explore such potential mechanisms and the context dependence of RSA reactivity effects, for example by probing the role of RSA reactivity depending on migrants' experiences and life histories (e.g., drivers for immigration or presence of trauma).

In terms of RSA recovery, we found that returning close to or above baseline after a discrimination-recall task was associated with greater mainstream acculturation. Recovery is seldom considered in conjunction with resting and reactivity. These results provide promising initial evidence that effective physiological restoration after a stressor is associated with migrants' reports of mainstream cultural adoption. Future research should examine trajectory of changes in RSA throughout the task to examine their associations with acculturation processes.

Interestingly, resting RSA's effect size (small to medium $\beta = .24$) was similar to that of reactivity and recovery, supporting the notion that these three Rs of cardiac vagal control provide complementary information in explaining mainstream acculturation. Mainstream acculturation was used here as a model of the successful navigation of a novel environment. In future research, it would be interesting to investigate the role of these three Rs in other conceptually similar contexts, such as starting a new job or integrating a new sports team.

Limitations and Strengths

This study was cross-sectional, which precludes any causality conclusions. Because of their considerable stability over long time periods (Bornstein & Suess, 2000), RSA indices are conceptualized as individual differences. This is consistent with the notion that these physiological variables may influence mainstream acculturation, rather than the opposite. However, there is evidence that resting RSA can fluctuate to some extent in response to life events and stressors such as migration (Gouin et al., 2015). For example, it is possible that people who have acculturated to the mainstream culture to a greater extent because of various other individual differences (e.g., openness to experience of self-efficacy) are under less chronic stress as a result. This may in turn have led to increases in RSA (Brosschot et al., 2017; Thayer et al., 2009). Longitudinal research will be necessary to conclusively establish temporal precedence.

Further, RSA reactivity levels are somewhat task-dependent. We used a discrimination-recall task but it would be important to test whether our results generalize to other tasks, such as for example, positive social interactions. Another design-related limitation concerns the varying lengths of time preceding recovery recordings. We considered participants recounting their memories as part of the overall laboratory task, but how much this lack of time standardization affected our results is unclear.

Conclusion

This study expanded the range of traditional predictors (i.e., sociodemographic or personality variables) of acculturation by considering the role of cardiac vagal control. The inclusion of all three R's of cardiac vagal control in a single study—especially recovery—is a novel feature of the present work and heeds the need to better characterize antecedents of mainstream acculturation. Mainstream acculturation can serve as a model of how individuals successfully navigate novel social environments, thus highlighting this study's broader theoretical significance to social psychology. These data suggest that one's physiological states—as indexed by RSA—are associated with mainstream acculturation and perceived discrimination among Maghrebi migrants to Canada. The findings highlight that in addition to social and psychological factors, acculturation is a process also

influenced by individual differences in physiology. Further research is needed to understand the interplay among RSA, perceived discrimination, and mainstream acculturation over time in racialized migrants, as well as the psychosocial pathways underlying these dynamic and potentially reciprocal processes.

References

- Adler, N. E., Epel, E. S., Castellazzo, G., & Ickovics, J. R. (2000). Relationship of subjective and objective social status with psychological and physiological functioning: Preliminary data in healthy white women. *Health Psychology, 19*(6), 586–592. <https://doi.org/10.1037/0278-6133.19.6.586>
- Balzarotti, S., Biassoni, F., Colombo, B., & Ciceri, M. (2017). Cardiac vagal control as a marker of emotion regulation in healthy adults: A review. *Biological Psychology, 130*, 54–66. <https://doi.org/10.1016/j.biopsycho.2017.10.008>
- Beauchaine, T. P. (2015). Respiratory sinus arrhythmia: A transdiagnostic biomarker of emotion dysregulation and psychopathology. *Current Opinion in Psychology, 3*, 43–47. <https://doi.org/10.1016/j.copsy.2015.01.017>
- Beauchaine, T. P., Bell, Z., Knapton, E., McDonough-Caplan, H., Shader, T., & Zisner, A. (2019). Respiratory sinus arrhythmia reactivity across empirically based structural dimensions of psychopathology: A meta-analysis. *Psychophysiology, 56*(5), Article e13329. <https://doi.org/10.1111/psyp.13329>
- Beauchaine, T. P., Gatzke-Kopp, L., Neuhaus, E., Chipman, J., Reid, M. J., & Webster-Stratton, C. (2013). Sympathetic- and parasympathetic-linked cardiac function and prediction of externalizing behavior, emotion regulation, and prosocial behavior among preschoolers treated for ADHD. *Journal of Consulting and Clinical Psychology, 81*(3), 481–493. <https://doi.org/10.1037/a0032302>
- Berntson, G. G., Bigger, J. T., Jr., Eckberg, D. L., Grossman, P., Kaufmann, P. G., Malik, M., Nagaraja, H. N., Porges, S. W., Saul, J. P., Stone, P. H., & Van Der Molen, M. W. (1997). Heart rate variability: Origins, methods, and interpretive caveats. *Psychophysiology, 34*(6), 623–648. <https://doi.org/10.1111/j.1469-8986.1997.tb02140.x>
- Berry, J. W. (2005). Acculturation: Living successfully in two cultures. *International Journal of Intercultural Relations, 29*(6), 697–712. <https://doi.org/10.1016/j.ijintrel.2005.07.013>
- Berry, J. W., & Hou, F. (2016). Immigrant acculturation and wellbeing in Canada. *Canadian Psychology, 57*(4), 254–264. <https://doi.org/10.1037/cap0000064>
- Bornstein, M. H., & Suess, P. E. (2000). Child and mother cardiac vagal tone: Continuity, stability, and concordance across the first 5 years. *Developmental Psychology, 36*(1), 54–65. <https://doi.org/10.1037/0012-1649.36.1.54>
- Breusch, T. S., & Pagan, A. R. (1979). A simple test for

heteroscedasticity and random coefficient variation. *Econometrica*, 47(5), 1287–1294. <https://doi.org/10.2307/1911963>

Brondolo, E., Rahim, R., Grimaldi, S. J., Ashraf, A., Bui, N., & Schwartz, J. C. (2015). Place of birth effects on self-reported discrimination: Variations by type of discrimination. *International Journal of Intercultural Relations : IJIR*, 49, 212–222. <https://doi.org/10.1016/j.ijintrel.2015.10.001>

Brosschot, J. F., Verkuil, B., & Thayer, J. F. (2017). Exposed to events that never happen: Generalized unsafety, the default stress response, and prolonged autonomic activity. *Neuroscience and Biobehavioral Reviews*, 74(Part B), 287–296. <https://doi.org/10.1016/j.neubiorev.2016.07.019>

Demes, K. A., & Geeraert, N. (2014). Measures matter: Scales for adaptation, cultural distance, and acculturation orientation revisited. *Journal of Cross-Cultural Psychology*, 45(1), 91–109. <https://doi.org/10.1177/0022022113487590>

Diamond, L. M., & Hicks, A. M. (2005). Attachment style, current relationship security, and negative emotions: The mediating role of physiological regulation. *Journal of Social and Personal Relationships*, 22(4), 499–518. <https://doi.org/10.1177/0265407505054520>

Diamond, L. M., Hicks, A. M., & Otter-Henderson, K. D. (2011). Individual differences in vagal regulation moderate associations between daily affect and daily couple interactions. *Personality and Social Psychology Bulletin*, 37(6), 731–744. <https://doi.org/10.1177/0146167211400620>

Doucerain, M. M. (2019). Moving forward in acculturation research by integrating insights from cultural psychology. *International Journal of Intercultural Relations*, 73, 11–24. <https://doi.org/10.1016/j.ijintrel.2019.07.010>

Doucerain, M. M. (2020, July). *Acculturation in hyper-diverse settings: The beneficial role of “third culture” social engagement*. International Association of Cross-Cultural Psychology.

Doucerain, M. M., Deschênes, S. S., Aubé, K., Ryder, A. G., & Gouin, J.-P. (2016). Respiratory Sinus Arrhythmia is prospectively associated with early trajectories of acculturation among new international students. *Journal of Cross-Cultural Psychology*, 47(3), 421–440. <https://doi.org/10.1177/0022022115624015>

Fox, J., & Weisberg, S. (2019). *An R companion to applied regression* (3rd ed.). Sage Publications. <https://socialsciences.mcmaster.ca/jfox/Books/Companion/>

Gouin, J.-P., Caldwell, W. C., MacNeil, S. L., & Roddick, C. M. (2019). Respiratory sinus arrhythmia reactivity moderates within-person associations of daily capitalization with positive affect and relationship quality. *Journal of Social and Personal Relationships*, 36(9), 2896–2917. <https://doi.org/10.1177/0265407518804669>

Gouin, J.-P., Deschênes, S. S., & Dugas, M. J. (2014). Respiratory sinus arrhythmia during worry forecasts stress-related increases in psychological distress. *Stress (Amsterdam, Netherlands)*, 17(5), 416–422.

<https://doi.org/10.3109/10253890.2014.949666>

Gouin, J.-P., Zhou, B., & Fitzpatrick, S. (2015). Social integration prospectively predicts changes in heart rate variability among individuals undergoing migration stress. *Annals of Behavioral Medicine*, 49(2), 230–238. <https://doi.org/10.1007/s12160-014-9650-7>

Graham, J. R., Calloway, A., & Roemer, L. (2015). The buffering effects of emotion regulation in the relationship between experiences of racism and anxiety in a Black American sample. *Cognitive Therapy and Research*, 39(5), 553–563. <https://doi.org/10.1007/s10608-015-9682-8>

Graziano, P., & Derefinko, K. (2013). Cardiac vagal control and children’s adaptive functioning: A meta-analysis. *Biological Psychology*, 94(1), 22–37. <https://doi.org/10.1016/j.biopsycho.2013.04.011>

Hartwell, S. W., & Benson, P. R. (2007). Social integration: A conceptual overview and two case studies. In W. R. Avison, J. D. McLeod, & B. A. Pescosolido (Eds.), *Mental health, social mirror* (pp. 329–354). Springer.

James, G., Witten, D., Hastie, T., & Tibshirani, R. (2017). *An introduction to statistical Learning: With applications in R* (1st ed. 2013, Corr. 7th printing 2017 édition). Springer.

Jamshidian, M., & Jalal, S. (2010). Tests of homoscedasticity, normality, and missing completely at random for incomplete multivariate data. *Psychometrika*, 75(4), 649–674. <https://doi.org/10.1007/s11336-010-9175-3>

Jasinskaja-Lahti, I., Liebkind, K., Horenczyk, G., & Schmitz, P. (2003). The interactive nature of acculturation: Perceived discrimination, acculturation attitudes and stress among young ethnic repatriates in Finland, Israel and Germany. *International Journal of Intercultural Relations*, 27(1), 79–97. [https://doi.org/10.1016/S0147-1767\(02\)00061-5](https://doi.org/10.1016/S0147-1767(02)00061-5)

Kang, S.-M. (2006). Measurement of acculturation, scale formats, and language competence: Their implications for adjustment. *Journal of Cross-Cultural Psychology*, 37(6), 669–693. <https://doi.org/10.1177/0022022106292077>

Kemp, A. H., Quintana, D. S., Gray, M. A., Felmingham, K. L., Brown, K., & Gatt, J. M. (2010). Impact of depression and antidepressant treatment on heart rate variability: A review and meta-analysis. *Biological Psychiatry*, 67(11), 1067–1074. <https://doi.org/10.1016/j.biopsycho.2009.12.012>

Kirmayer, L. J., Narasiah, L., Munoz, M., Rashid, M., Ryder, A. G., Guzder, J., Hassan, G., Rousseau, C., Pottie, K., & The Canadian Collaboration for Immigrant and Refugee Health (CCIRH). (2011). Common mental health problems in immigrants and refugees: General approach in primary care. *Canadian Medical Association Journal*, 183(12), E959–E967. <https://doi.org/10.1503/cmaj.090292>

Kosic, A. (2006). Personality and individual factors in acculturation. In D. L. Sam & J. W. Berry (Eds.), *Cambridge handbook of acculturation psychology* (pp. 113–128). Cambridge University Press. <https://doi.org/10>

.1017/CBO9780511489891.011

Laborde, S., Mosley, E., & Mertgen, A. (2018). Vagal tank theory: The three Rs of cardiac vagal control functioning—resting, reactivity, and recovery. *Frontiers in Neuroscience*, *12*, Article 458. <https://doi.org/10.3389/fnins.2018.00458>

Lüdecke, D., Ben-Shachar, M., Patil, I., Waggoner, P., & Makowski, D. (2021). An R package for assessment, comparison and testing of statistical models. *Journal of Open Source Software*, *6*(60), Article 3139. <https://doi.org/10.21105/joss.03139>

Malik, M., Bigger, T. J., Camm, A. J., Kleiger, R. E., Malliani, A., Moss, A. J., & Schwartz, P. J. (1996). Heart rate variability: Standards of measurement, physiological interpretation and clinical use. *European Heart Journal*, *17*(3), 354–381. Task force of the European society of cardiology and the North American society of pacing and electrophysiology. <https://doi.org/10.1093/oxfordjournals.eurheartj.a014868>

Maunder, R. G., Nolan, R. P., Hunter, J. J., Lancee, W. J., Steinhart, A. H., & Greenberg, G. R. (2012). Relationship between social support and autonomic function during a stress protocol in ulcerative colitis patients in remission. *Inflammatory Bowel Diseases*, *18*(4), 737–742. <https://doi.org/10.1002/ibd.21794>

Muhtadie, L., Koslov, K., Akinola, M., & Mendes, W. B. (2015). Vagal flexibility: A physiological predictor of social sensitivity. *Journal of Personality and Social Psychology*, *109*(1), 106–120. <https://doi.org/10.1037/pspp0000016>

Nangia, P. (2013). Discrimination experienced by landed immigrants in Canada (No. 2017/7; RCIS Working Papers). *Ryerson Centre for Immigration and Settlement*. <https://doi.org/10.13140/RG.2.1.2767.0168>

Neto, F. (2002). Acculturation strategies among adolescents from immigrant families in Portugal. *International Journal of Intercultural Relations*, *26*(1), 17–38. [https://doi.org/10.1016/S0147-1767\(01\)00036-0](https://doi.org/10.1016/S0147-1767(01)00036-0)

Nguyen, A. D., & Benet-Martínez, V. (2013). Biculturalism and adjustment: A meta-analysis. *Journal of Cross-Cultural Psychology*, *44*(1), 122–159. <https://doi.org/10.1177/0022022111435097>

Noh, S., & Kaspar, V. (2003). Perceived discrimination and depression: Moderating effects of coping, acculturation, and ethnic support. *American Journal of Public Health*, *93*(2), 232–238. <https://doi.org/10.2105/AJPH.93.2.232>

Park, G., Vasey, M. W., Van Bavel, J. J., & Thayer, J. F. (2014). When tonic cardiac vagal tone predicts changes in phasic vagal tone: The role of fear and perceptual load. *Psychophysiology*, *51*(5), 419–426. <https://doi.org/10.1111/psyp.12186>

Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology*, *74*(2), 116–143. <https://doi.org/10.1016/j.biopsycho.2006.06.009>

Porges, S. W. (2011). *The polyvagal theory: Neurophysiological foundations of emotions, attachment, communication, self-regulation*. WW Norton.

Quintana, D. S., Guastella, A. J., Outhred, T., Hickie, I. B., & Kemp, A. H. (2012). Heart rate variability is associated with emotion recognition: Direct evidence for a relationship between the autonomic nervous system and social cognition. *International Journal of Psychophysiology: Official Journal of the International Organization of Psychophysiology*, *86*(2), 168–172. <https://doi.org/10.1016/j.ijpsycho.2012.08.012>

R Core Team. (2020). *R: A language and environment for statistical computing*. *R Foundation for Statistical Computing*. <https://www.Rproject.org/>

Sam, D. L., & Berry, J. W. (2010). Acculturation: When individuals and groups of different cultural backgrounds meet. *Perspectives on Psychological Science*, *5*(4), 472–481. <https://doi.org/10.1177/1745691610373075>

Schwartz, S. J., Unger, J. B., Zamboanga, B. L., & Szapocznik, J. (2010). Rethinking the concept of acculturation: Implications for theory and research. *American Psychologist*, *65*(4), 237–251. <https://doi.org/10.1037/a0019330>

Sloan, R. P., Huang, M.-H., Sidney, S., Liu, K., Williams, O. D., & Seeman, T. (2005). Socioeconomic status and health: Is parasympathetic nervous system activity an intervening mechanism? *International Journal of Epidemiology*, *34*(2), 309–315. <https://doi.org/10.1093/ije/dyh381>

Smith, T. W., Cribbet, M. R., Nealey-Moore, J. B., Uchino, B. N., Williams, P. G., Mackenzie, J., & Thayer, J. F. (2011). Matters of the variable heart: Respiratory sinus arrhythmia response to marital interaction and associations with marital quality. *Journal of Personality and Social Psychology*, *100*(1), 103–119. <https://doi.org/10.1037/a0021136>

Smith, T. W., Deits-Lebehn, C., Williams, P. G., Baucom, B. R. W., & Uchino, B. N. (2020). Toward a social psychophysiology of vagally mediated heart rate variability: Concepts and methods in self-regulation, emotion, and interpersonal processes. *Social and Personality Psychology Compass*, *14*(3), Article e12516. <https://doi.org/10.1111/spc3.12516>

Statistics Canada. (2017a, February 8). *Focus on Geography Series, 2016 Census—Canada*. <https://www12.statcan.gc.ca/census-recensement/2016/as-sa/fogs-spg/Facts-can-eng.cfm?Lang=Eng&GK=CANGC=01&TOPIC=7>

Statistics Canada. (2017b, November 29). *Le Quotidien — La scolarité au Canada: Faits saillants du Recensement de 2016*. <https://www150.statcan.gc.ca/n1/daily-quotidien/171129/dq171129a-fra.htm>

Steinbeis, N., Engert, V., Linz, R., & Singer, T. (2015). The effects of stress and affiliation on social decision-making: Investigating the tend-and-befriend pattern. *Psychoneuroendocrinology*, *62*, 138–148.

<https://doi.org/10.1016/j.psyneuen.2015.08.003>

Te Lindert, A., Korzilius, H., Van De Vijver, F. J., Kroon, S., & Arends-Tóth, J. (2008). Perceived discrimination and acculturation among Iranian refugees in the Netherlands. *International Journal of Intercultural Relations*, 32(6), 578–588. <https://doi.org/10.1016/j.ijintrel.2008.09.003>

Thayer, J. F., Hansen, A. L., Saus-Rose, E., & Johnsen, B. H. (2009). Heart rate variability, prefrontal neural function, and cognitive performance: The neurovisceral integration perspective on self-regulation, adaptation, and health. *Annals of Behavioral Medicine*, 37(2), 141–153. <https://doi.org/10.1007/s12160-009-9101-z>

Umetani, K., Singer, D. H., McCraty, R., & Atkinson, M. (1998). Twentyfour hour time domain heart rate variability and heart rate: Relations to age and gender over nine decades. *Journal of the American College of Cardiology*, 31(3), 593–601. [https://doi.org/10.1016/S0735-1097\(97\)00554-8](https://doi.org/10.1016/S0735-1097(97)00554-8)

United Nations. (2011). *Combating discrimination against migrants*. Office of the High Commissioner for Human Rights. https://www.ohchr.org/en/issues/discrimination/pages/discrimination_migrants.aspx

Valiante, G. (2017 February 5). *Muslim immi-*

grant cabbies say they face discrimination in Quebec City job market. CBC News. <https://www.cbc.ca/news/canada/montreal/muslim-immigrant-job-market-1.3967841>

Verkuyten, M., & Yildiz, A. A. (2007). National (dis)identification and ethnic and religious identity: A study among Turkish-Dutch muslims. *Personality and Social Psychology Bulletin*, 33(10), 1448–1462. <https://doi.org/10.1177/0146167207304276>

Ward, C., & Geeraert, N. (2016). Advancing acculturation theory and research: The acculturation process in its ecological context. *Current Opinion in Psychology*, 8, 98–104. <https://doi.org/10.1016/j.copsy.2015.09.021>

Williams, D. P., Koenig, J., Carnevali, L., Sgoifo, A., Jarczok, M. N., Sternberg, E. M., & Thayer, J. F. (2019). Heart rate variability and inflammation: A meta-analysis of human studies. *Brain, Behavior, and Immunity*, 80, 219–226. <https://doi.org/10.1016/j.bbi.2019.03.009>

Williams, D. R., Yan Yu, D. R., Jackson, J. S., & Anderson, N. B. (1997). Racial differences in physical and mental health socio-economic status, stress and discrimination. *Journal of Health Psychology*, 2(3), 335–351. <https://doi.org/10.1177/135910539700200305>